Flows, Gusts, and Blasts from the Sun:

the

Nature of the Beast

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ZP13

for the
Alabama Power Grid Defense Conference
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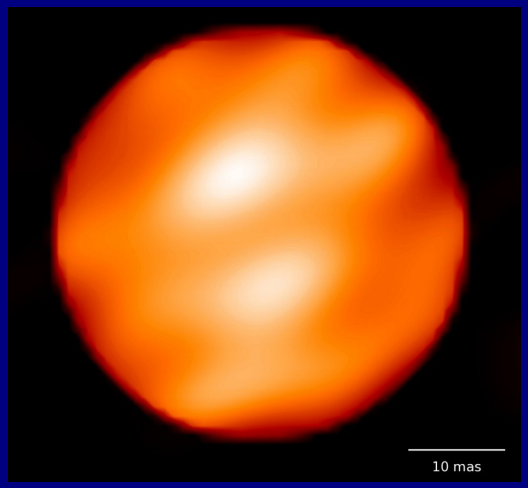
What is the
Sun?

The Sun: A Star at the Center of our Solar System

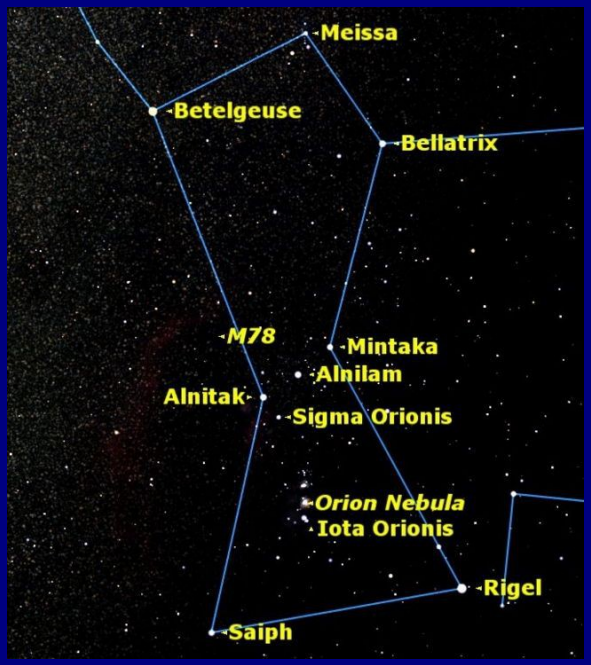
Planet Nine?

What is a Star?

A star is an astrophysical body that produces its own light by thermonuclear reactions in its core.

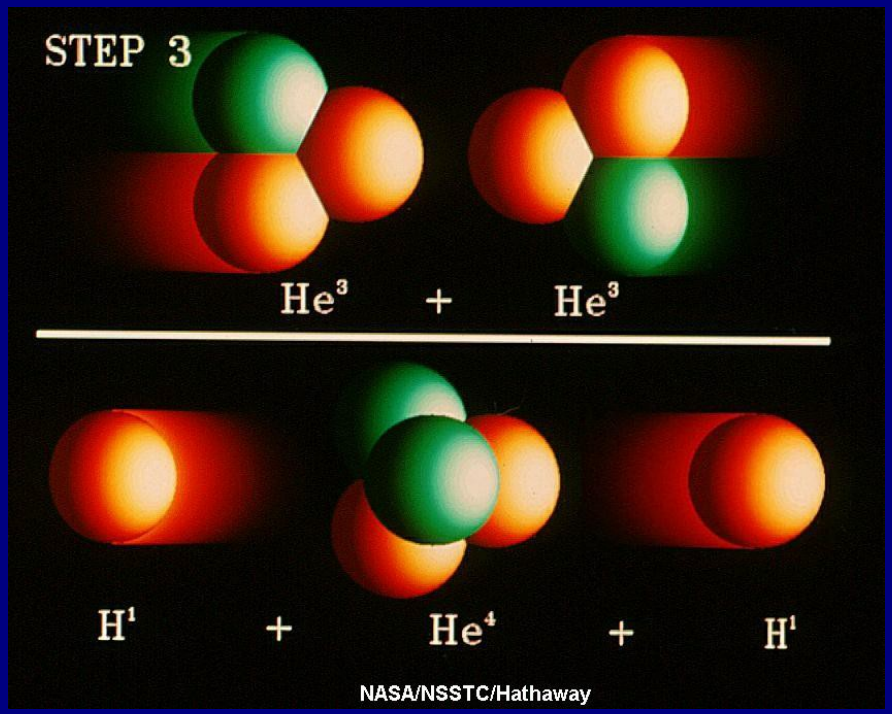


Betelgeuse: A red giant star, about 600 ly away, 3500 K, 1,180 $R_\odot$, 7.7 $M_\odot$.



Rigel: A blue-white star, about 770 ly away, 11,000 K, 80 $R_\odot$, 20 $M_\odot$.

Basically, hydrogen converts to Helium

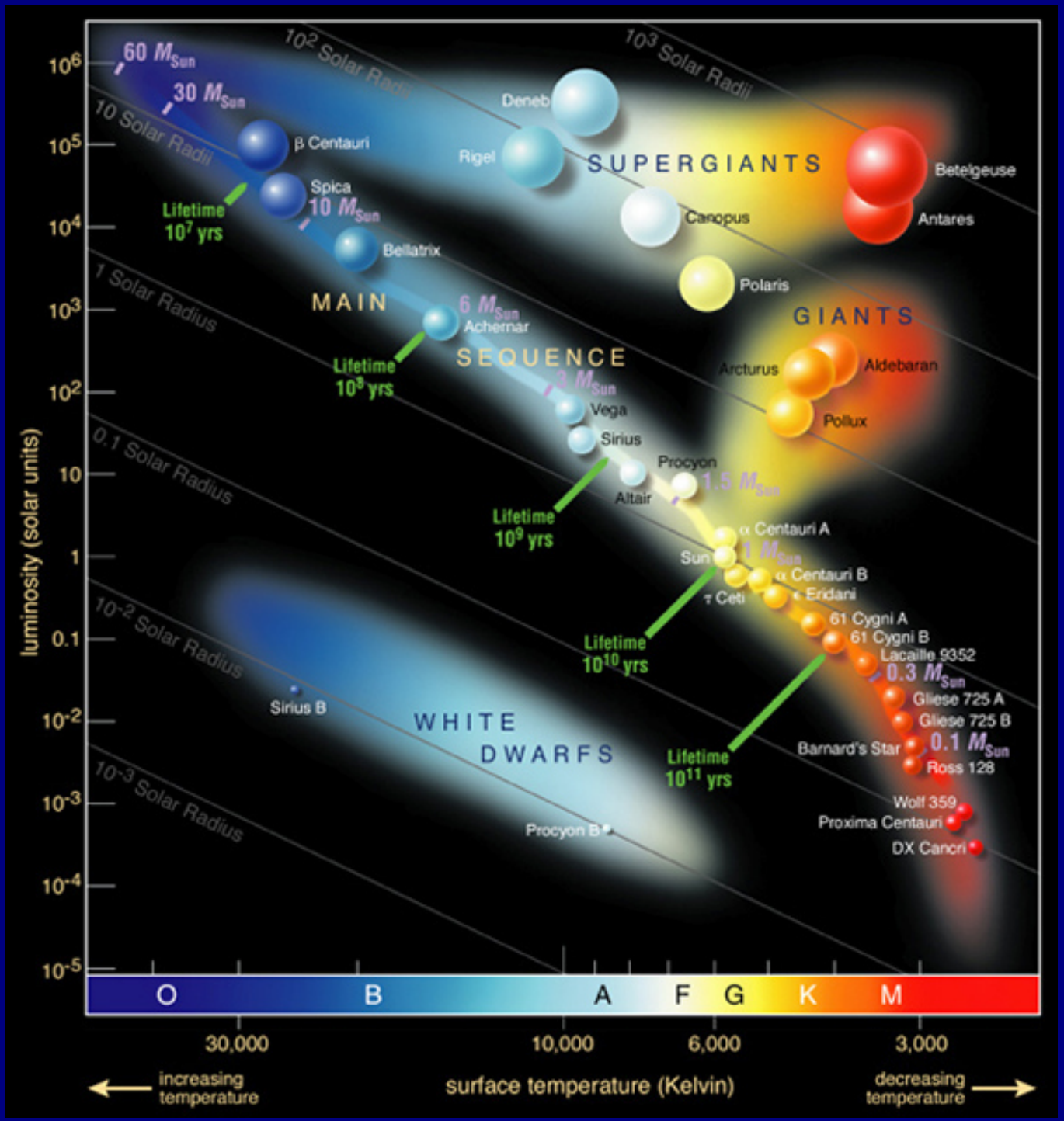


For sun-type stars, there are three steps in the proton-proton chain:

1. Two protons collide, form deuterium, a positron, and neutrino.
2. A proton collides with the deuterium, forming helium-3 and a gamma ray
3. Two He-3s collide to form He-4 plus two protons.

(High-mass stars, greater than about 2 solar masses use a different procedure, called the CNO cycle.)

Stellar Differences



α-Cen-A is G2,
α-Cen-B is K1,
Proxima (α-Cen-C) is M6,

the Sun is G2
8.5 light minutes away

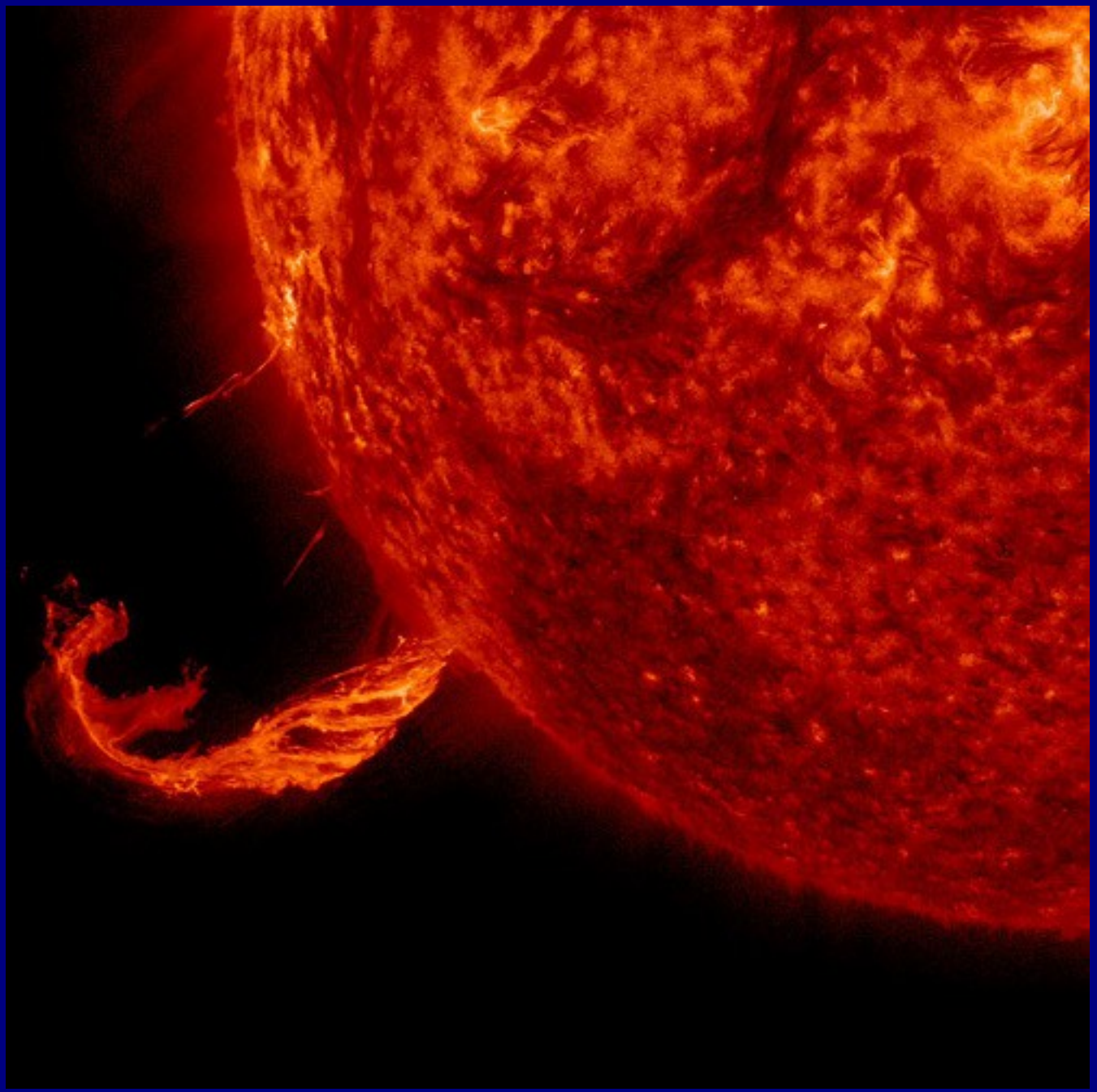
Betelgeuse is M2
643 ly

Bellatrix is B2
250 ly

Rigel is B8
860 ly

Saiph is B0
650 ly

The Sun -- How Big ? How Powerful ??



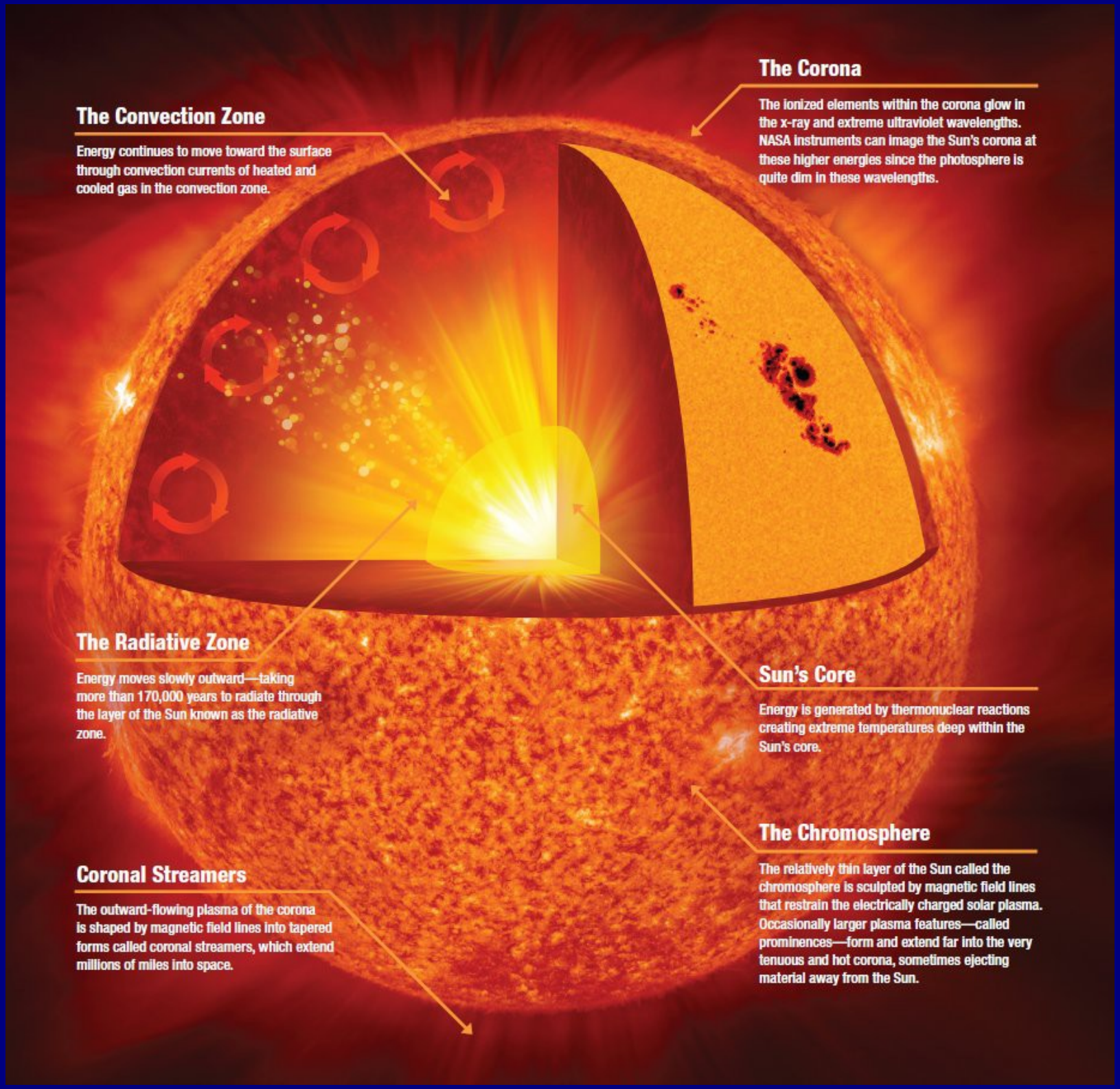
1.3 million Earths can fit inside the Sun

The Sun contains more than 99.8% of the total mass of the Solar System.

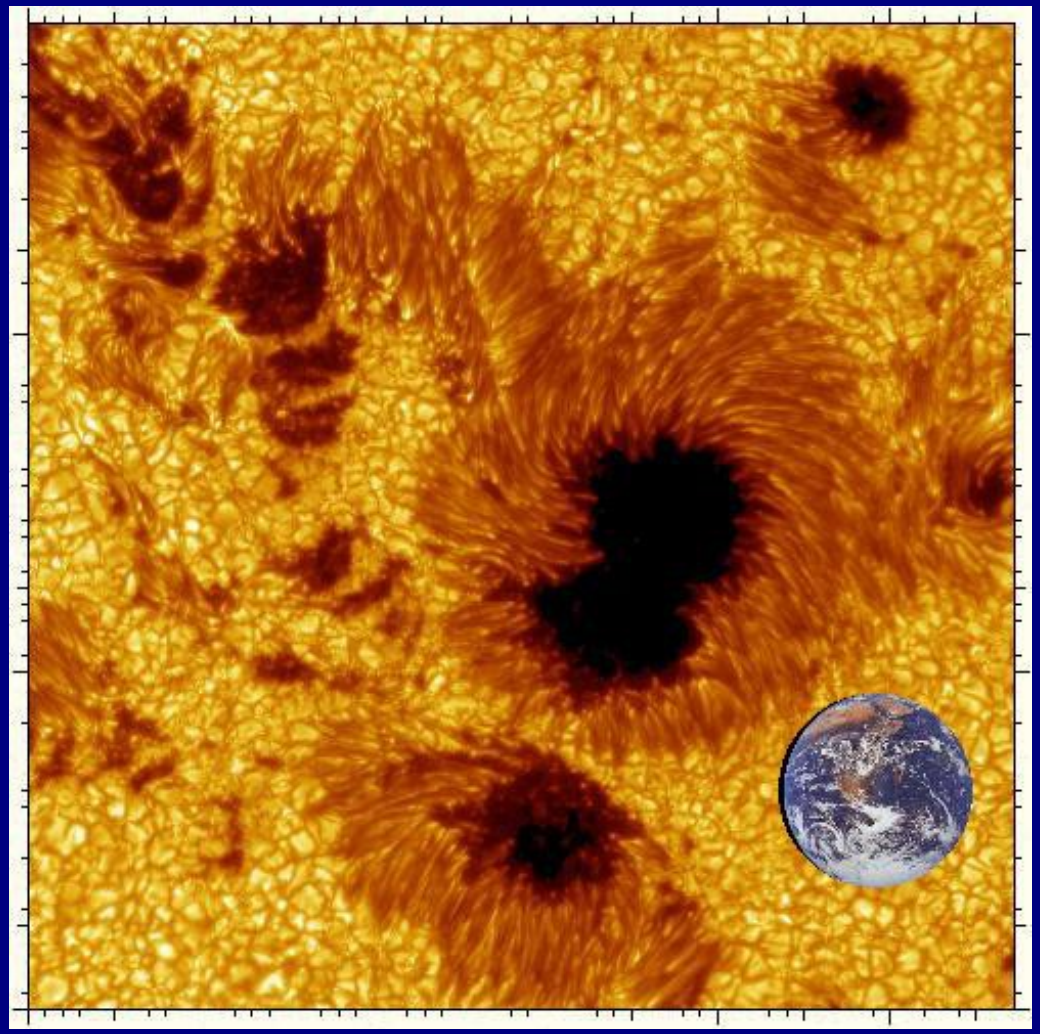
Pressure in the core is approximately 250 billion billion atmospheres

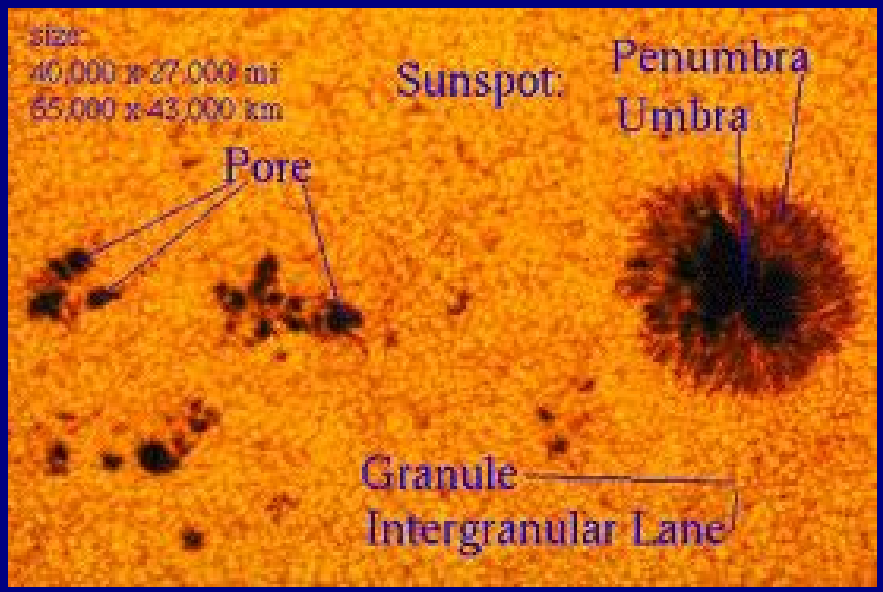
Energy conversion rate: 4.26 million metric tons/second, this produces approximately 38,460 septillion Watts/second

(Outburst304_big.mp4)


The Corona
The ionized elements within the corona glow in the x-ray and extreme ultraviolet wavelengths. NASA instruments can image the Sun's corona at these higher energies since the photosphere is quite dim in these wavelengths.
The Convection Zone
Energy continues to move toward the surface through convection currents of heated and cooled gas in the convection zone.
The Radiative Zone
Energy moves slowly outward—taking more than 170,000 years to radiate through the layer of the Sun known as the radiative zone.
Sun's Core
Energy is generated by thermonuclear reactions creating extreme temperatures deep within the Sun's core.
The Chromosphere
The relatively thin layer of the Sun called the chromosphere is sculpted by magnetic field lines that restrain the electrically charged solar plasma. Occasionally larger plasma features—called prominences—form and extend far into the very tenuous and hot corona, sometimes ejecting material away from the Sun.
Coronal Streamers
The outward-flowing plasma of the corona is shaped by magnetic field lines into tapered forms called coronal streamers, which extend millions of miles into space.

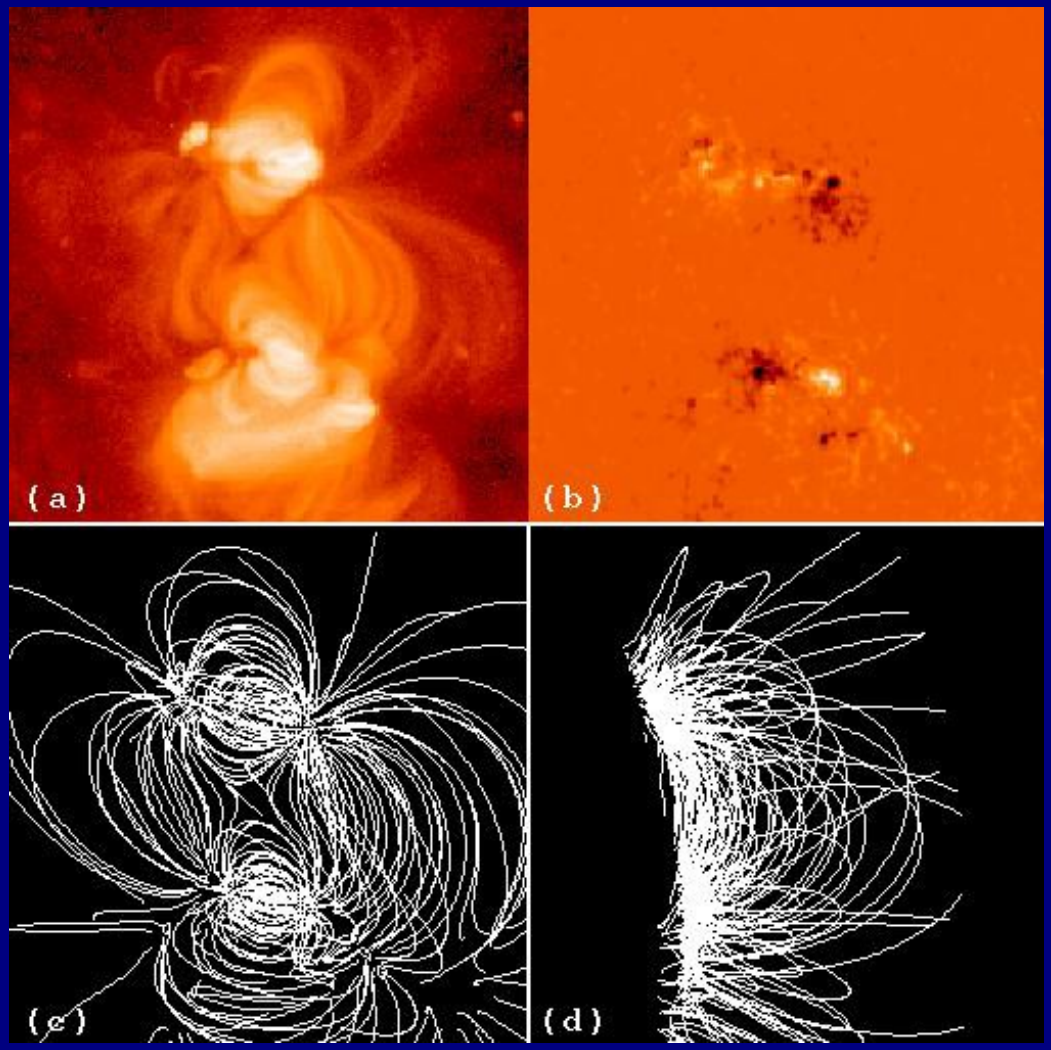
Sunspots
Examples





Magnetic Fields ABOVE the “Surface”

Yohkoh, 4 Jan, 1994



L-O-S magnetic field

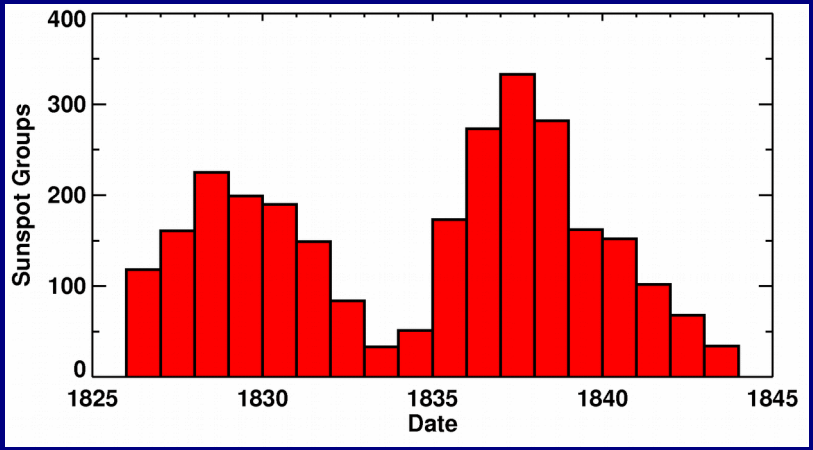
Extrapolated Magnetic Field

The Solar Cycle

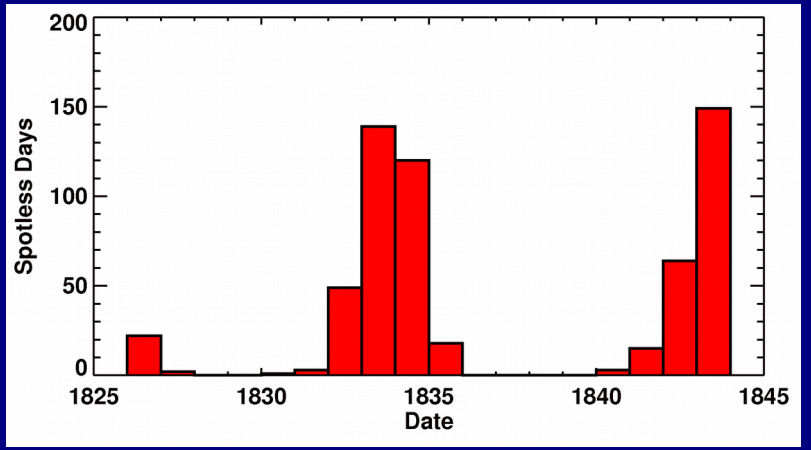
Sunspot Cycle Discovery

Astronomers had been observing sunspots for over 230 years before Heinrich Schwabe, an amateur astronomer in Dessau, Germany, discovered in 1844 that the number of sunspot groups and the number of days without sunspots increased and decreased in cycles of about 10-years.

Schwabe's data for 1826 to 1843

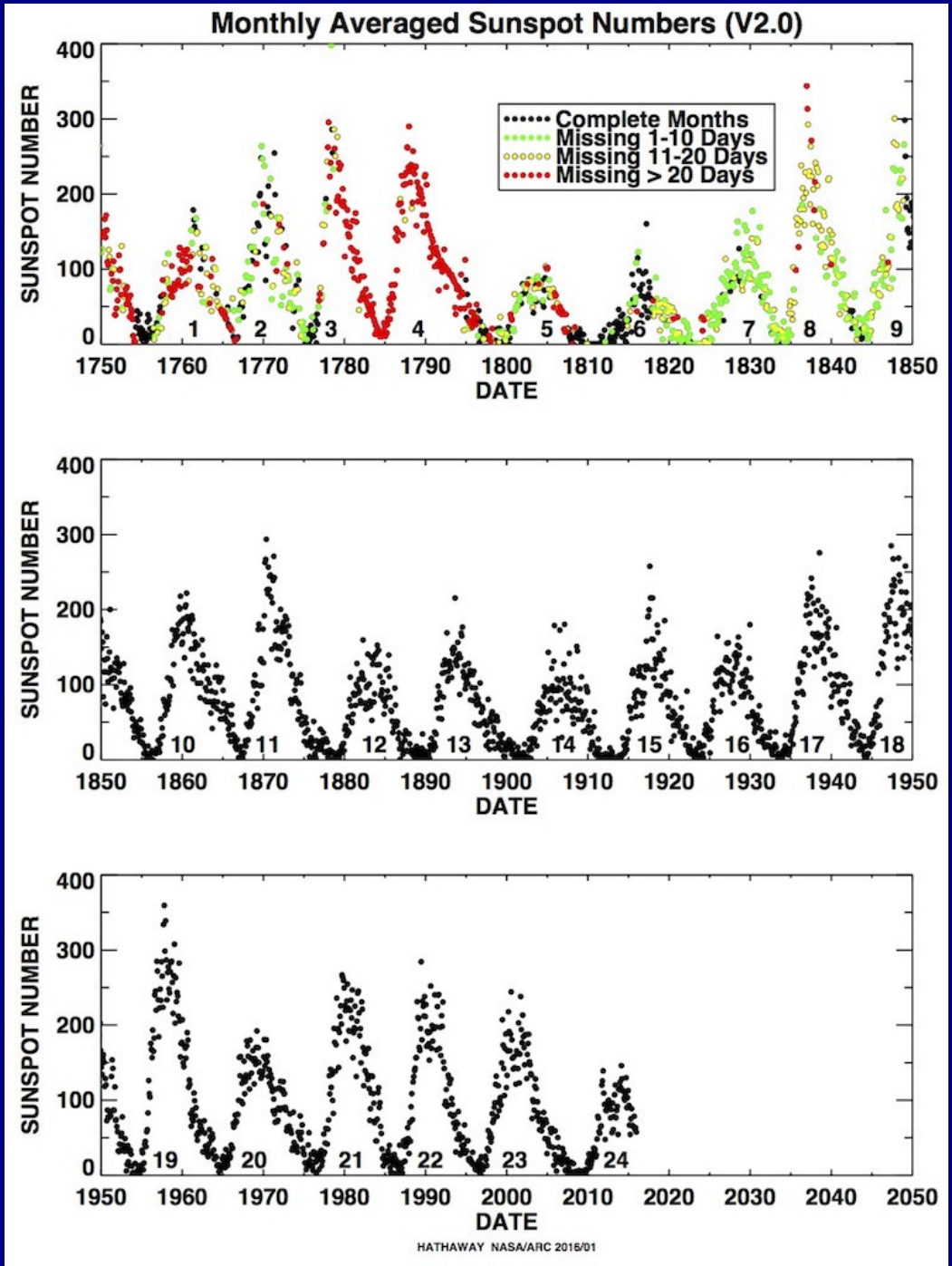


Number of Sunspot Groups per Year



Number of Spotless Days

23 Full Cycles



Shortly after Schawbe discovery Rudolf Wolf proposed using a "Relative" Sunspot Number count. While there were many days without observations prior to 1849, sunspots have been counted on every day since. To this day we continue to use Wolf's Relative Sunspot Number and his cycle numbering.

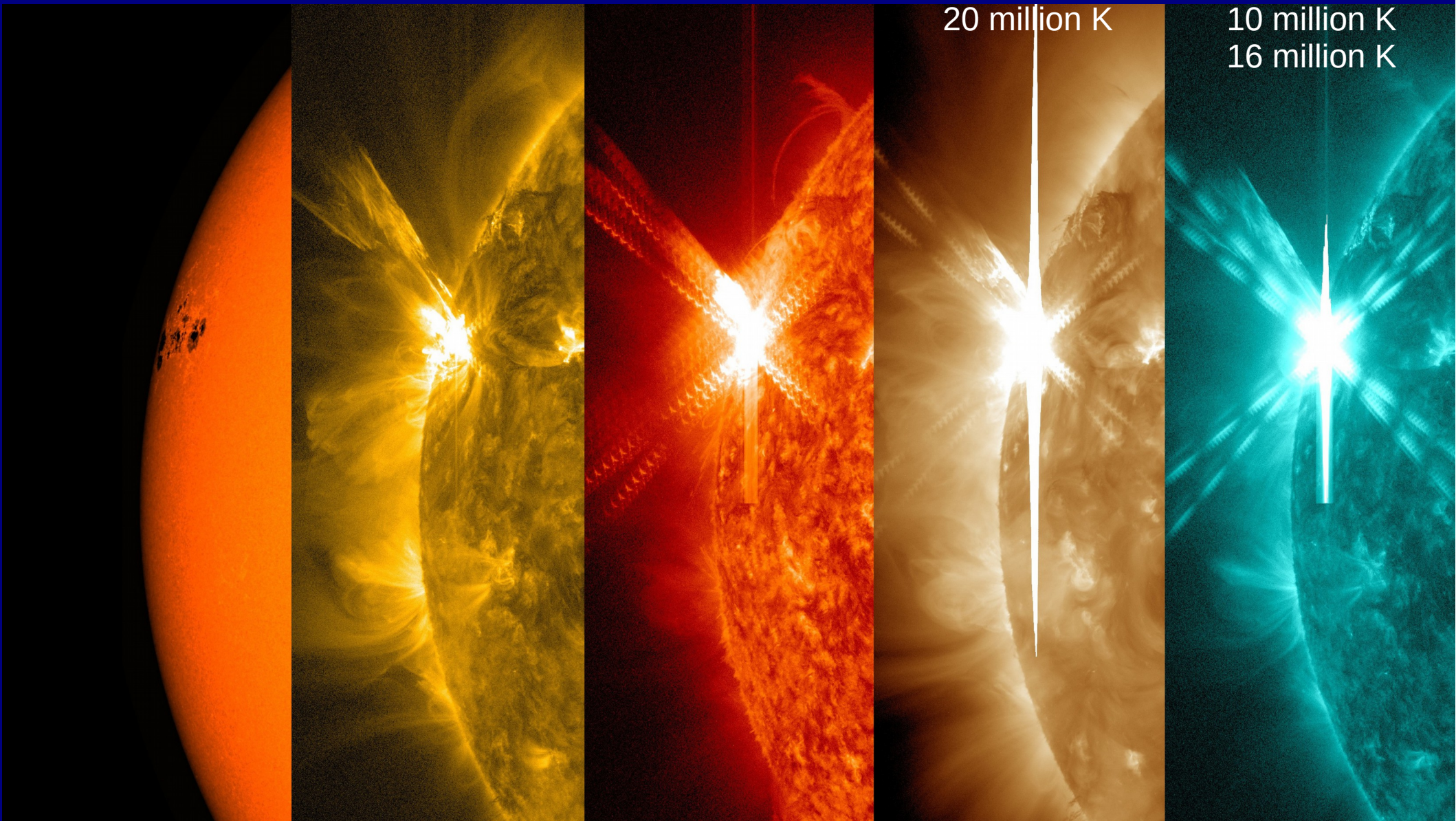
The average cycle lasts about 11 years, but with a range from 9 to 14.

The average amplitude is about 100, but with a range from 50 to 200.

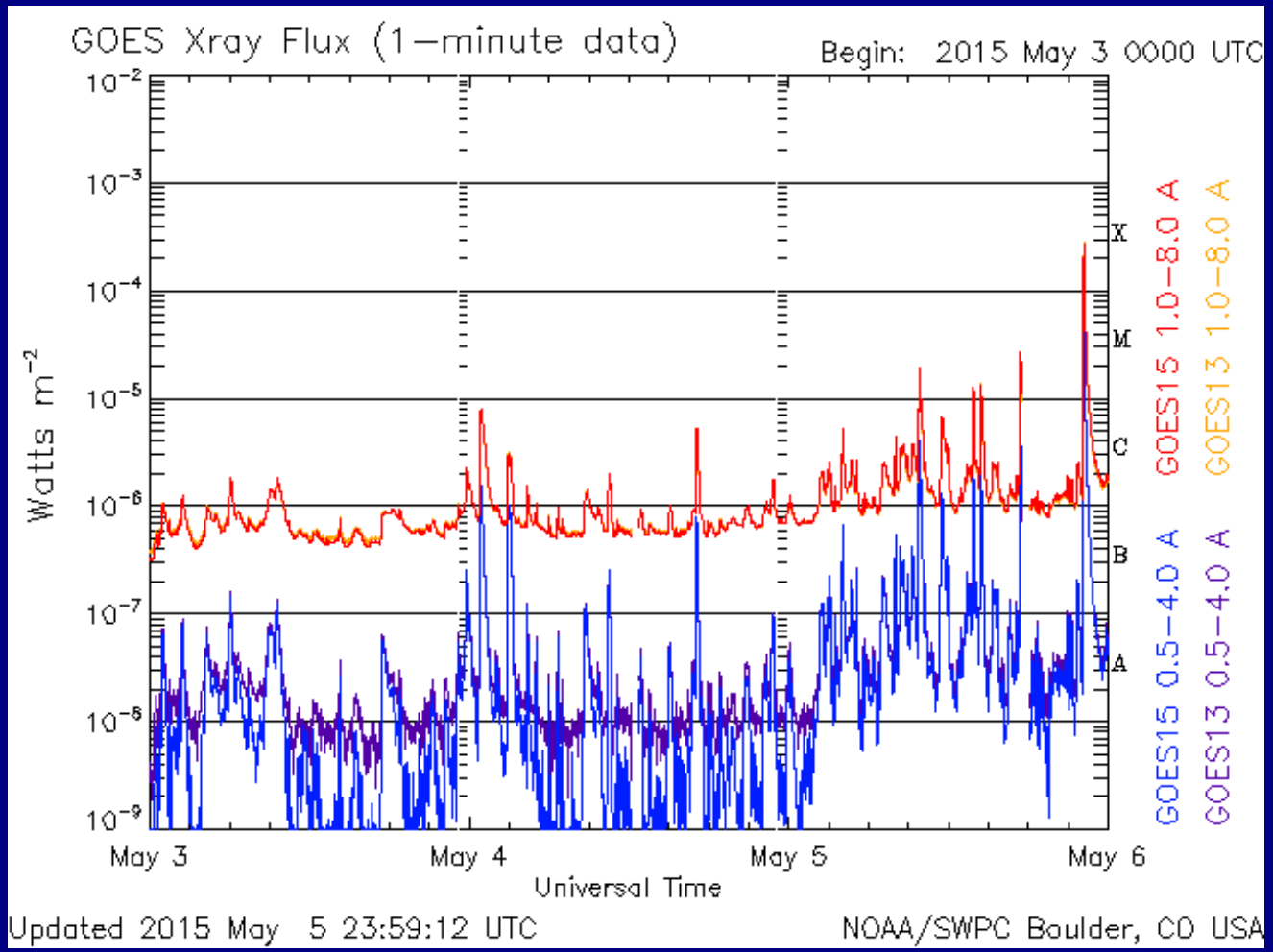
Solar Eruptions

Flares

May 5, 2015, X2.7 flare

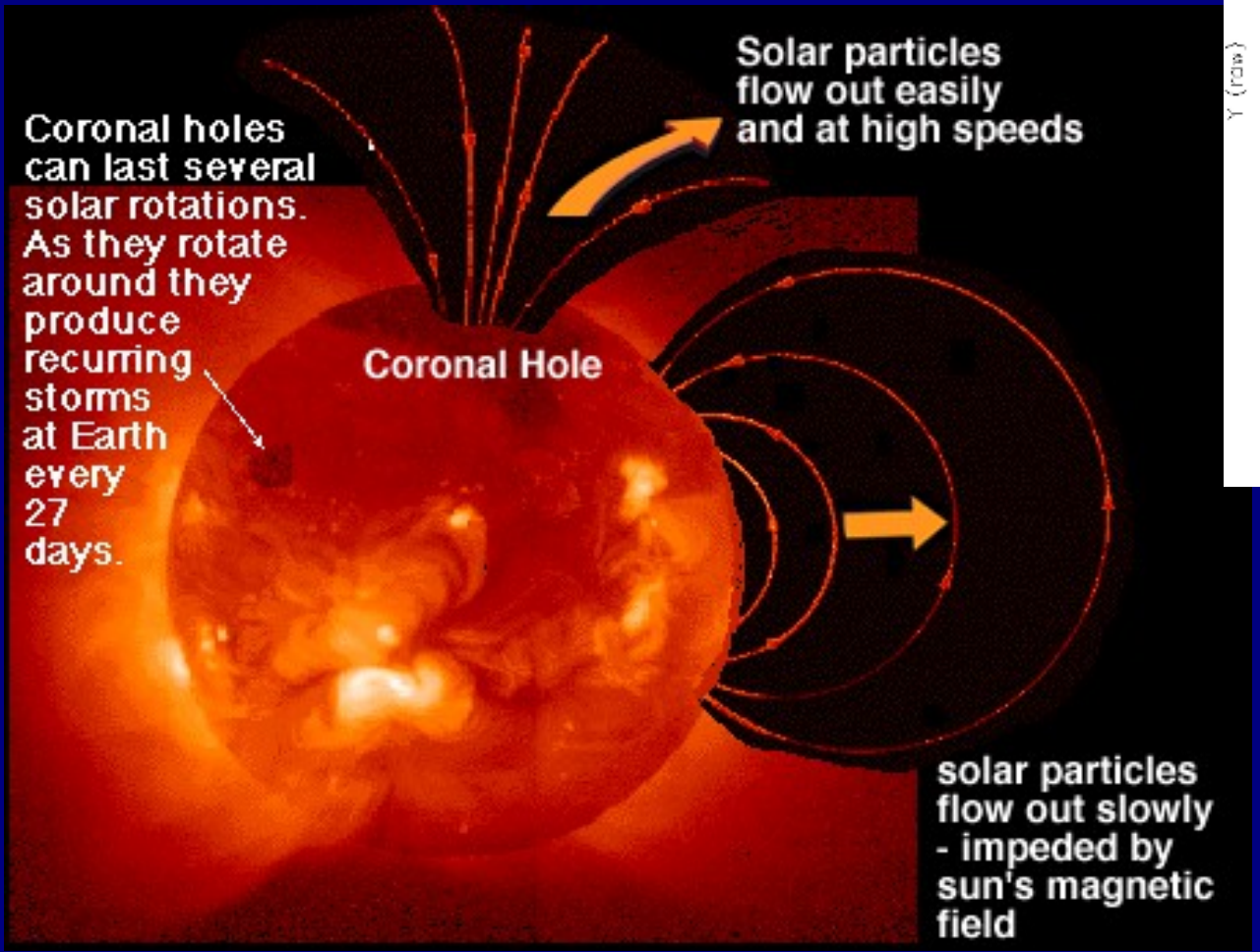


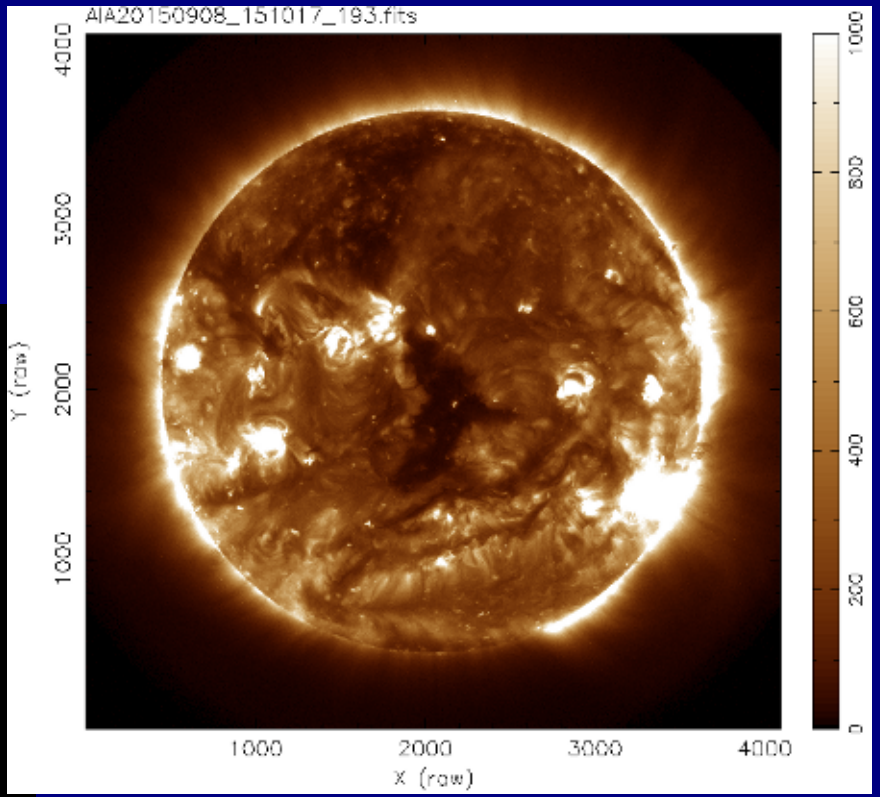
How to Classify a Solar Flare



Hiroshima Bomb ~ 15 kiloton TNT
A flare ~ 1 billion megaton tNT

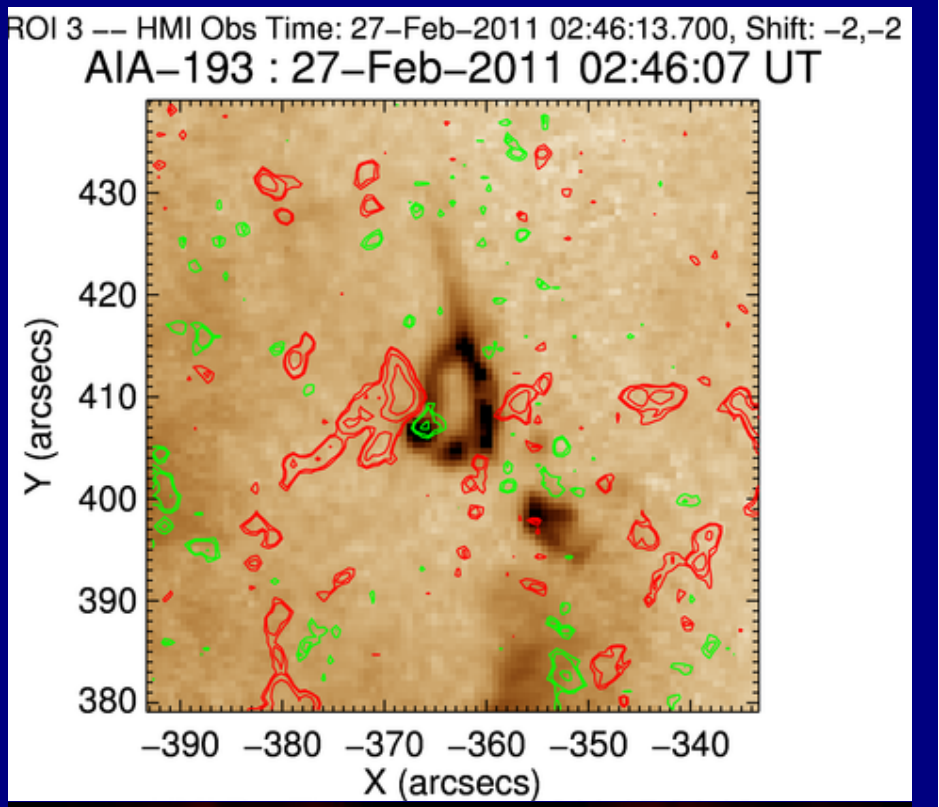
Coronal Holes as Seen in X rays and EUV

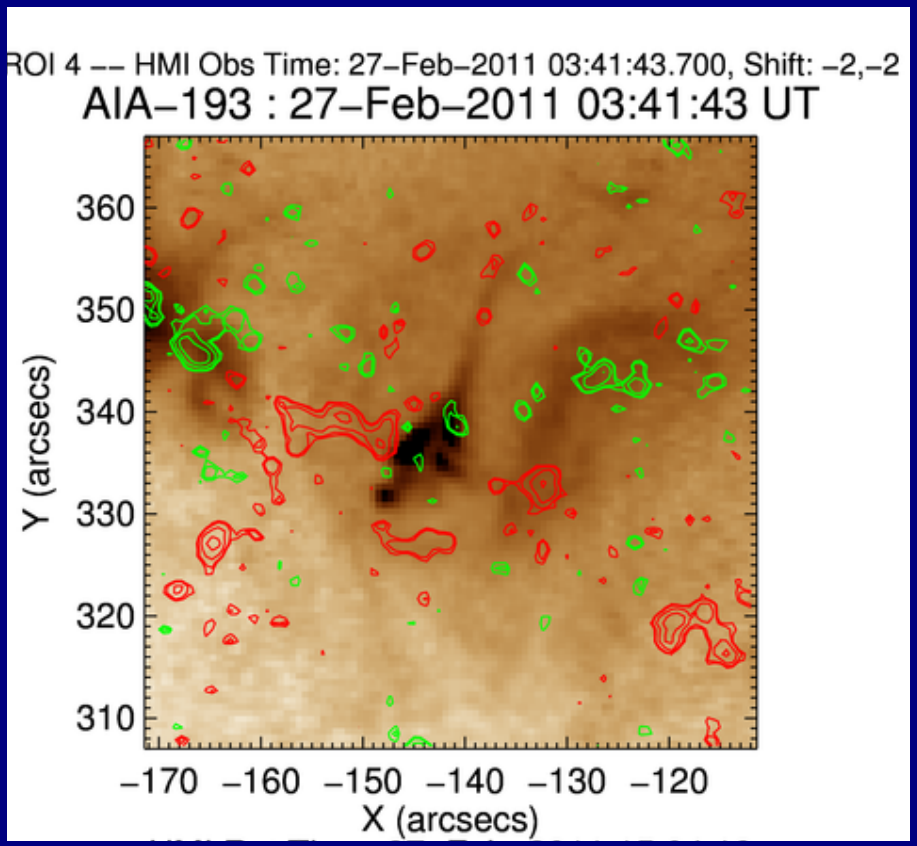


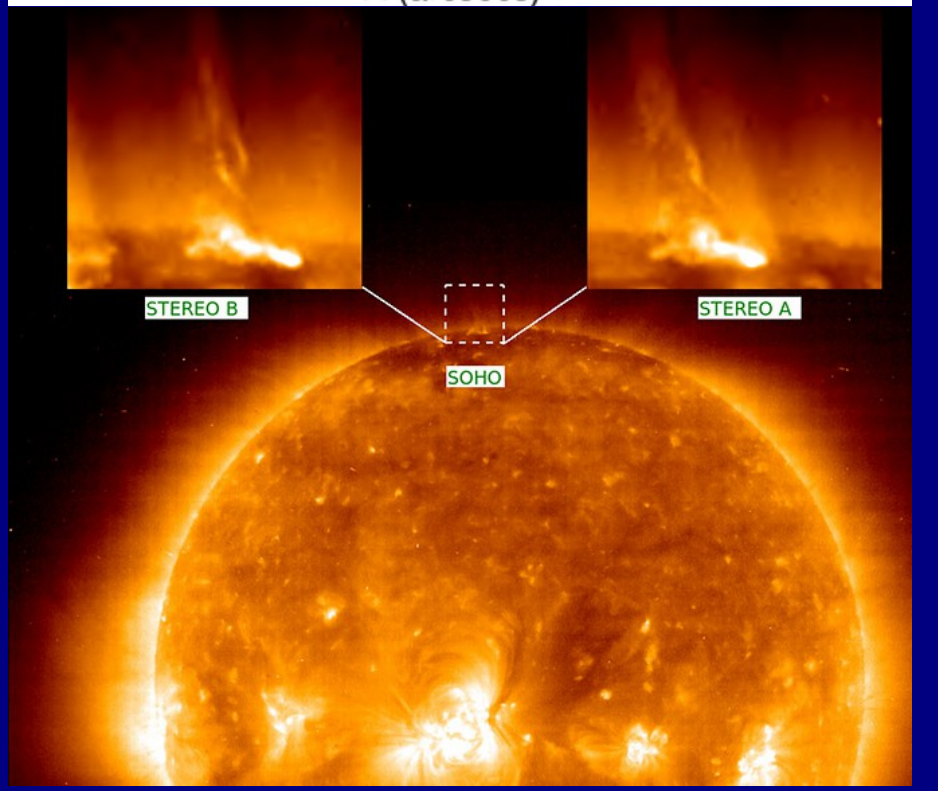


Jets in Coronal Holes

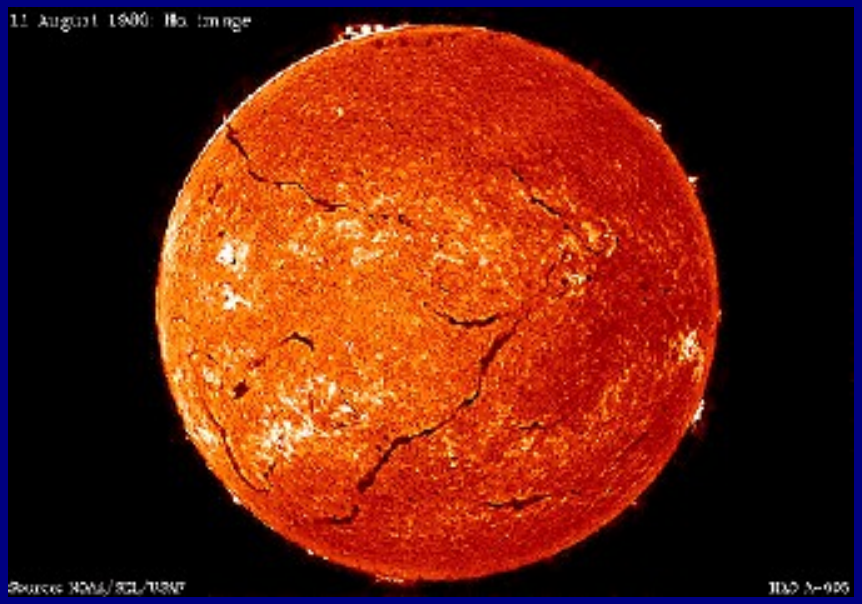
South Polar Jet: Hinode/P. Grigis

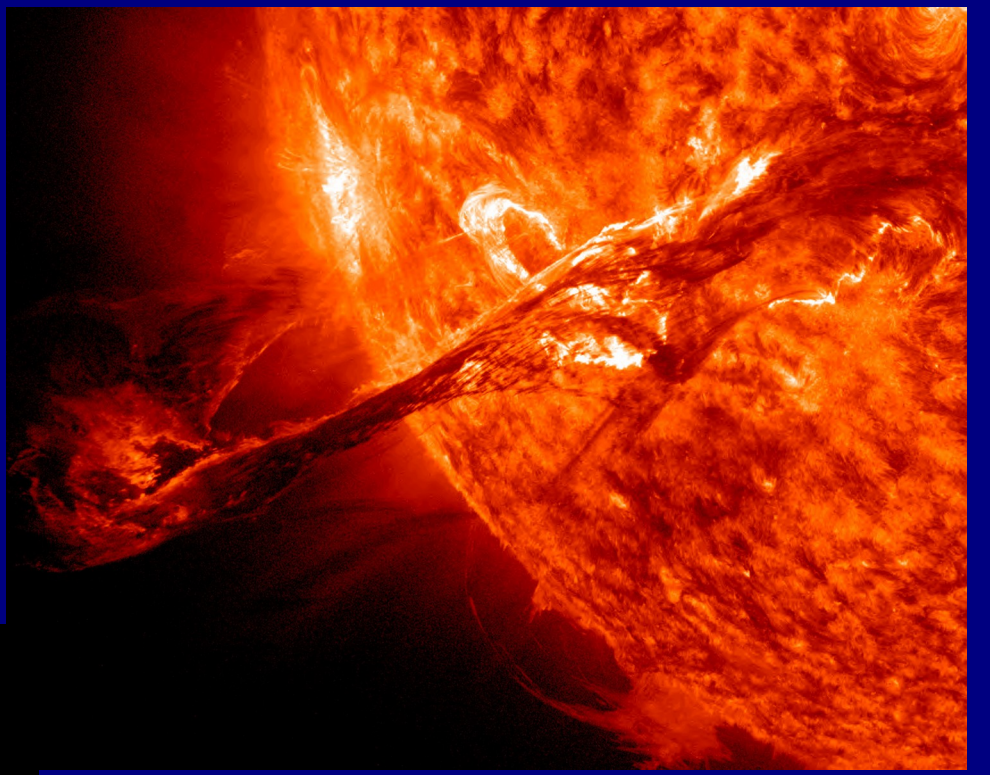




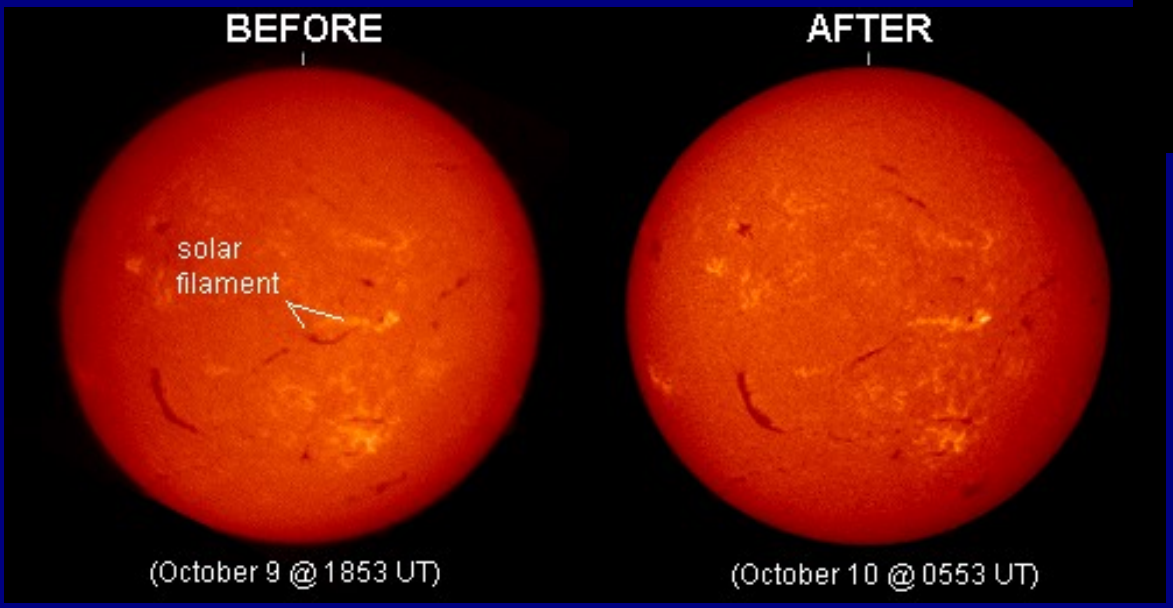


Filament eruptions





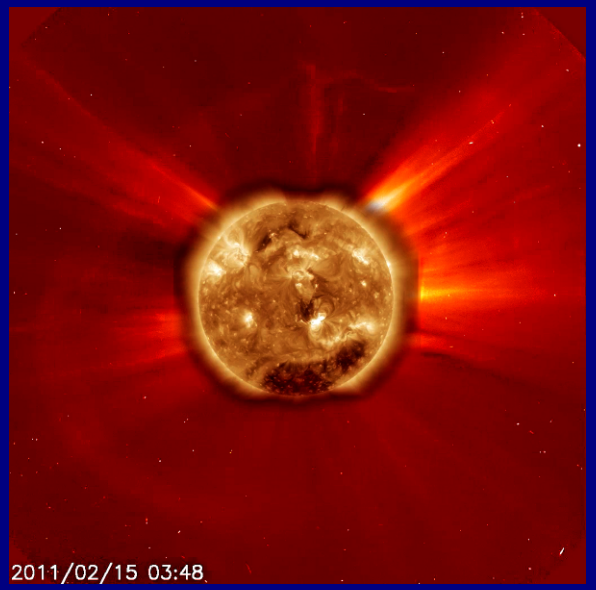
August 31, 2012, a filament erupted, triggering a CME. The plasma had speeds > 900 mi/s. This image is from SDO in 304 Å.



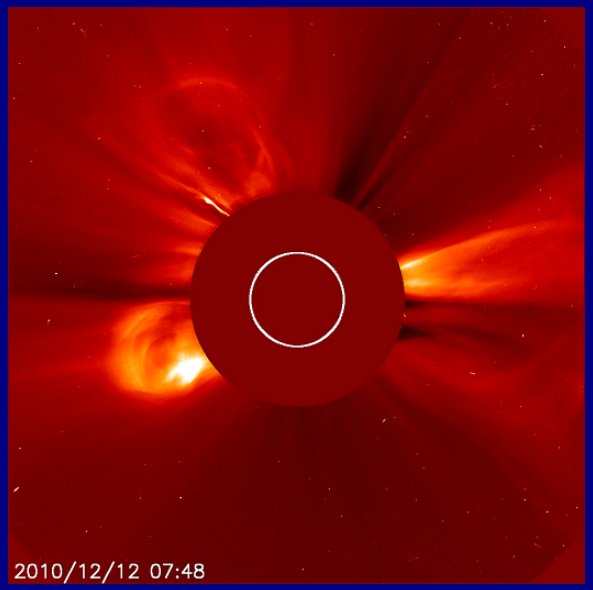
A filament around AR 9182 in October 2000. A C-7 flare was triggered, as well as a halo coronal-mass ejection (CME). Images from NOAA/SEC.

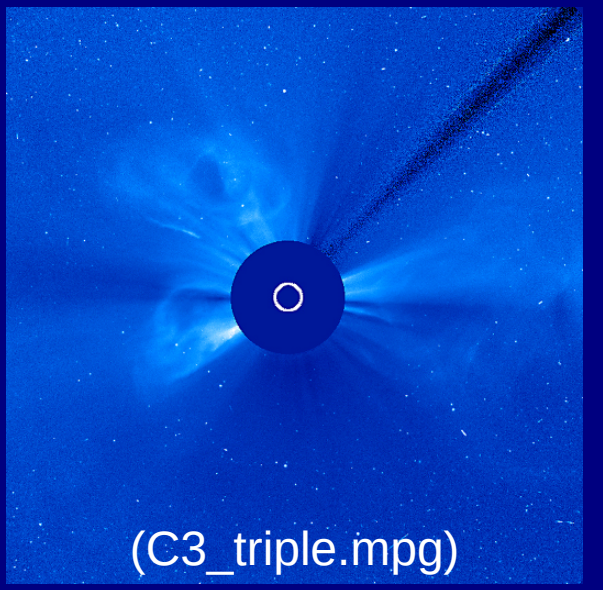
Other Types of Solar Eruptions

Solar Flares and Coronal Mass Ejections (CMEs)



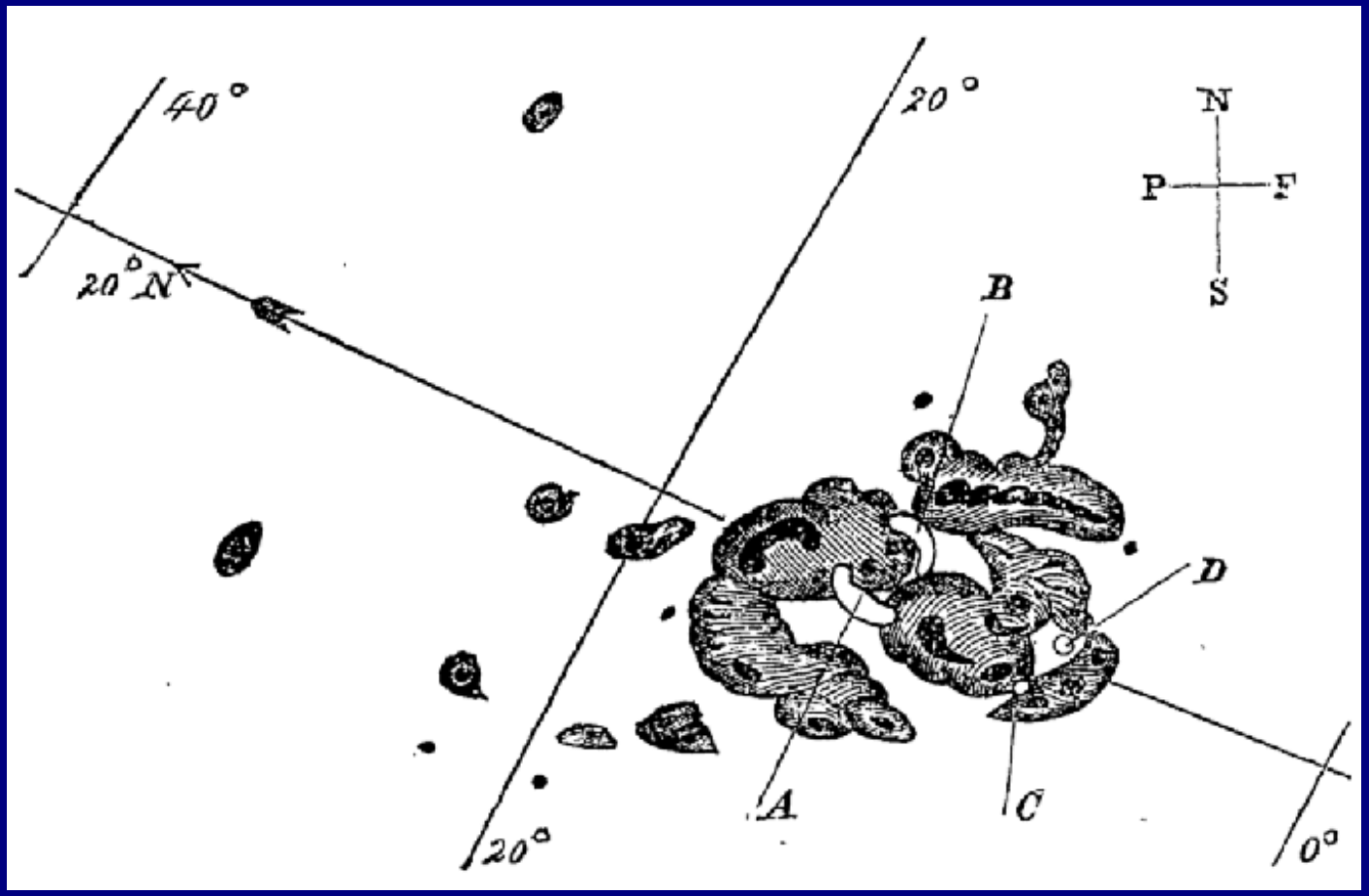
This combo of SDO and Soho C2 shows X2-flare and CME (X2_C2_combo_best.mpg)

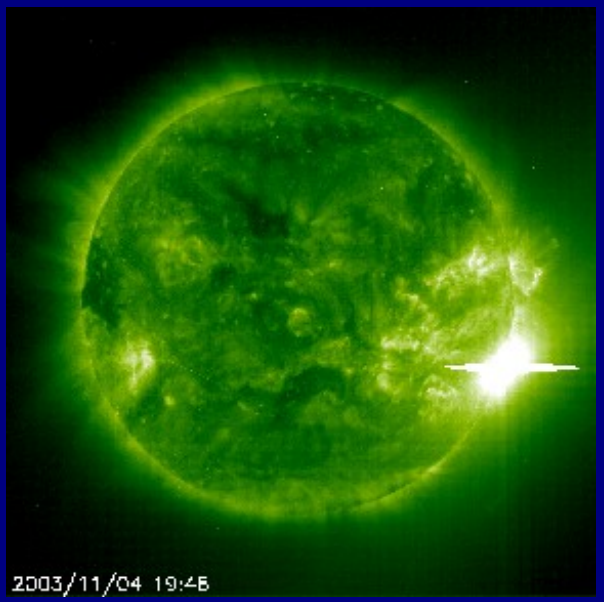




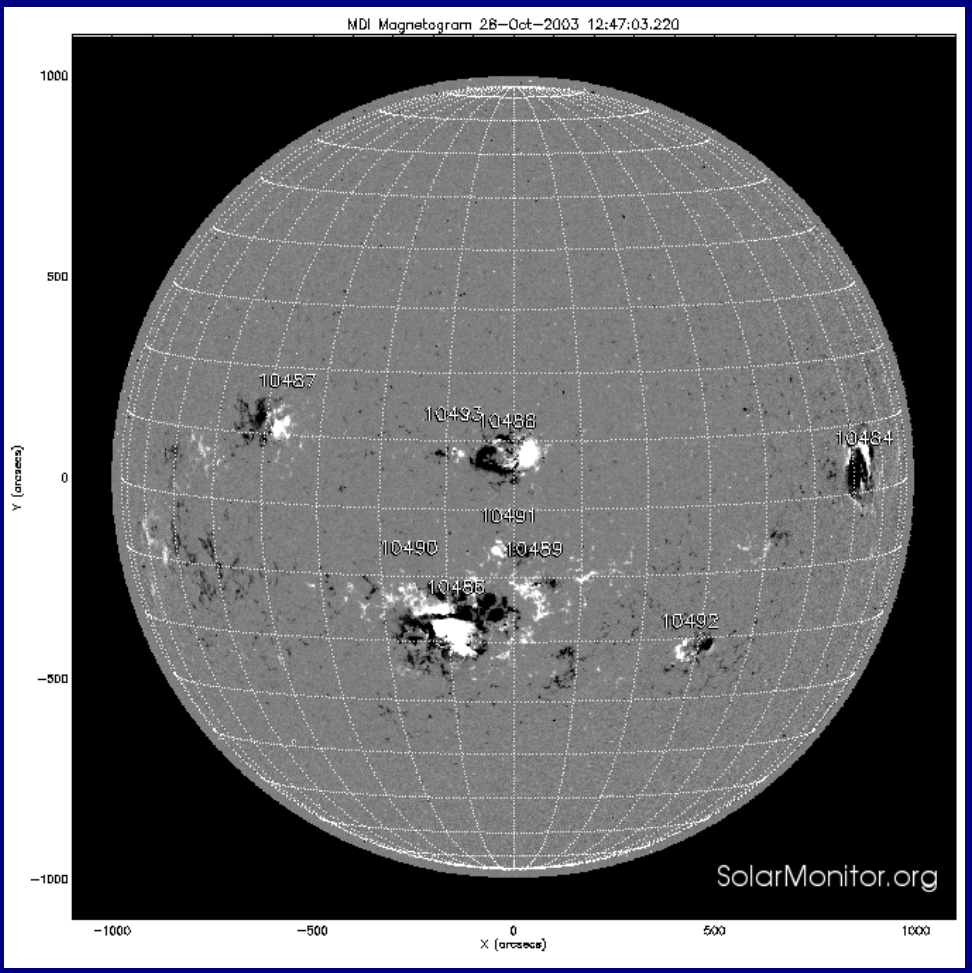
Three distinct CMEs: First (to right) was from a filament eruption, second from north pole, third from far side of Sun. All three eruptions happened within hours of each other.

August 28 - September 2, 1859
The Carrington Event
(and Richard Hodgson)





A brilliant display of Northern lights was witnessed from 8 o'clock to half-past 9 last night. The glare in the northern sky, previous to defining itself into the well-known features of the Aurora Borealis was sufficiently vivid to call out some of the fire companies. [The Evening Star (Washington DC]



…Large print could no doubt have been easily read, for we can testify that the time on the face of a watch was easily legible…[Washington Daily National Intelligencer, September 3, 1859].

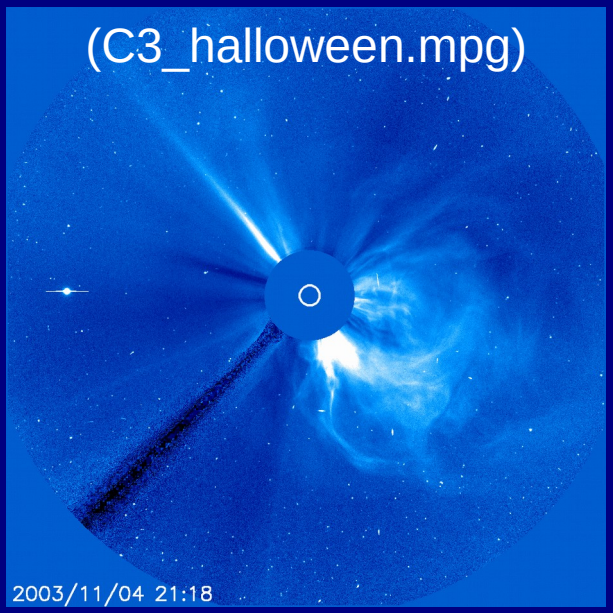
…The northern sky, for an extent of some forty five degrees, was luminous with a mass of red light, from whence shot up towards the zenith the usual streaks, at times vivid and beautiful…[New Orleans Daily Picayune, September 3, 1859].

…There were strong currents of electricity observed on the wires, to which no batteries were attached, and some extraordinary electrical phenomena, difficulty of explanation, noticed…
[New Orleans Daily Picayune, Saturday, September 3, 1859].

…The wire was then worked for about two hours without the usual batteries on the auroral current, working better than with the batteries connected. This is the first instance on record of more than a word or two having been transmitted with the auroral current…[Washington Daily National Intelligencer, Tuesday, September 6, 1859].

…The French telegraph communications at Paris were greatly affected, and on interrupting the circuit of the conducting wire strong sparks were observed. The same thing occurred at the same time at all the telegraphic station in France…
[The Illustrated London News, September 24, 1859].

(C3_halloween.mpg)



The Great American Solar Eclipse

August 21, 2017

National Aeronautics and Space Administration

What is a Solar Eclipse?

A solar eclipse happens when the Moon, as it orbits Earth, fully or partially blocks the light of the Sun, thus **casting its shadow on Earth**.

Observers within the ***path of totality*** can expect to see something like the image below. Observers outside the path of totality will see the Sun partially eclipsed as a crescent Sun (with safe filters).

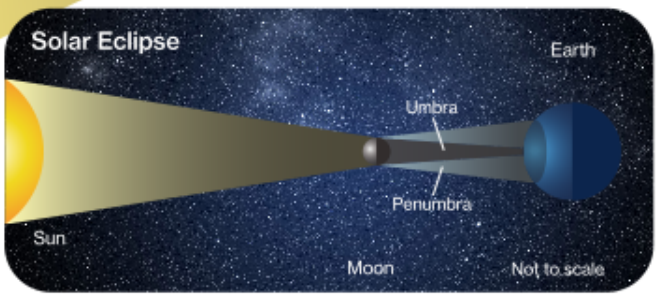
Maximum Eclipse

Time	Location
10:17am PDT	Lincoln Beach, OR
	Depoe Bay, OR
11:26am MDT	Lime, ID
1:19pm CDT	Valley View, MO
	Bloomsdale, MO
1:26pm CDT	Hopkinsville, KY
1:28pm CDT	Calistia, TN
2:47pm EDT	Bethera, SC

After the 2017 solar eclipse, the next total solar eclipse visible over the continental United States will be on April 8, 2024.

The last total solar eclipse to cover this much of the country was on June 8, 1918.

©1999 by F. Espenak, MrEclipse.com



©1999, Photos by F. Espenak used with permission. MrEclipse.com.

If the Sun is scaled to about 10 cm (3.9 in), Earth would be about 10 meters away (33 feet).

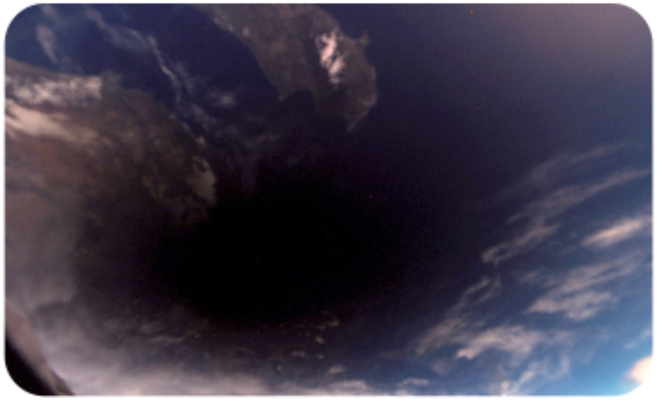
The predicted path of the August 21, 2017 solar eclipse

Duration of Greatest Eclipse:
2 min 40 sec
(18:25 UT=13:25 CDT or 1:25 p.m. CDT)

Location of Greatest Eclipse:
36 deg 58 min N; 87 deg 40 min W
(between Princeton, KY and Hopkinsville, KY)

Path Width: approximately 115 km

Eclipse predictions by Fred Espenak, GSFC, NASA Emeritus



http://mail.colonial.net/~hkalter/index.html

The NASA image above shows the Moon's **umbral shadow** as seen from the International Space Station during the total solar eclipse on 29 March 2006.

Never look directly at the Sun unless you have filters that you know are safe.

For more information: http://eclipse/gsfc.nasa.gov/SEhelp/safety.html
For more information about solar eclipses: http://eclipse.gsfc.nasa.gov/solar.html
http://eclipsewise.com/solar
www.nasa.gov http://eclipse2017.org/

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